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Original article

Validation of resting metabolic rate equations in obese and non-obese young healthy adults

Hayder Al-Domi*, Alaa Al-Shorman

Department of Nutrition and Food Science, School of Agriculture, The University of Jordan, Amman 11942, Jordan

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SUMMARY

Background and aims: Although validating resting metabolic rate (RMR) prediction equations in different populations is warranted to estimate total energy requirements, there are no data about the accuracy and applicability of RMR predictive equations in young healthy Jordanians. This study aimed to test the validity of predicted RMR using four prediction equations and its agreement with RMR measured using indirect calorimetry in healthy young obese and non-obese Jordanian adults.
Methods: Predicted RMR was tested for agreement with indirect calorimetry. Harris–Benedict, Food and Agriculture Organization/World Health Organization/United Nations University, Mifflin and Owen equations were used to predict RMR. A total of 406 (200 females, 206 males) normal bodyweight, overweight, and obese healthy young adults aged 18–25 years were included.
Results: Of all tested equations, Harris–Benedict equation showed no significant differences compared to measured RMR using indirect calorimetry ($p > 0.05$) in normal bodyweight (1374.1 ± 72.5 vs. 1347.6 ± 333.4), overweight (1513.1 ± 66.8 vs. 1492.9 ± 374.8) and obese (1673.5 ± 178.4 vs. 1736.4 ± 386.9) females. While significant differences ($p<0.05$) were found in all male participants. The other studied equations showed significant differences ($p \leq 0.05$) compared to measured RMR in gender based groups with different bodyweight status.
Conclusion: Only Harris–Benedict equation was the most accurate in predicting RMR among females regardless of bodyweight status. Apart from that, these equations did not perform well at the group level. The tested prediction equations further underestimated RMR. Future studies aiming at validating RMR prediction equations in different populations are warranted in order to understand the factors that could affect the accuracy of RMR prediction.

1. Introduction

Resting metabolic rate (RMR) is described as the quantity of energy released from an individual at resting state per unit of time; however, the utilized and released energy in this state is sufficient for vital organs functioning [1]. Measuring RMR is essential for determining both resting energy expenditure and total energy requirements. Thus, it has become an increasingly important tool in nutrition status assessment and care plan, maintaining healthy bodyweight as well as scientific research, in order to estimate total energy requirements [2].

The traditional indirect calorimetery is the “golden standard” method for assessing RMR by which RMR is estimated in vivo from carbon dioxide and oxygen exchange measurements [3]. Using indirect calorimetry could not be feasible in every setting since it is time consuming and requires specialized equipment. Therefore, practical measures such as using prediction equations in estimating total energy expenditure remain necessary [4]. Although the prediction equations provide an easy method to estimate RMR, the accuracy of which likely varies across individuals and group levels, thus, validating RMR prediction equations could marginally provide means to calculate energy requirements in various populations. Food and Agriculture Organization/World Health Organization/United Nations University (FAO/WHO/UNU) [5], Mifflin [6], Harris-Benedict [7], and Owen [8] equations are among a

Abbreviations: RMR, resting metabolic rate; FAO/WHO/UNU, Food and Agriculture Organization/ World Health Organization/ United Nations University; BMR, basal metabolic rate; WC, waist circumferences; HC, hip circumferences; WHR, Waist -to-hip ratio; BMI, body mass index.

* Corresponding author. Fax: +00962 6 5300806.
E-mail addresses: h.aldomi@ju.edu.jo (H. Al-Domi), alaa.a.shorman@hotmail.com (A. Al-Shorman).

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wide range of widely used, simple, quick and easy to perform RMR prediction equations.

Harris–Benedict equation was first introduced in 1919 for estimating basal metabolic rate (BMR). Nevertheless, a previous report suggested that Harris–Benedict equation estimates RMR rather than BMR since the study participants did not spend the night in the test facility [9]. FAO/WHO/UNU equations are based on the work of Schofield and colleagues [10], which were developed based on Western populations [10]. Additionally, Owen [8] and Mifflin [6] equations were more recently introduced. While Owen equation [8] was based on a small sample size with wide range of body sizes and ages, Mifflin equation [6] was more accurate in predicting RMR in different settings and populations worldwide as compared to the other tested RMR prediction equations [9,11]. Accurate determination of RMR using various prediction equations and the reliability of these equations in different populations and different settings remain inconsistent and requires further validation [12].

The rampant increase of overweight and obesity in both developed and developing populations, regardless of geographic location, socioeconomic status or age groups, has been described as a global pandemic, which highlights an alarming worldwide health challenge. The global combined prevalence of overweight and obesity rose by 47.1% for children and 27.5% for adults [13]. This could be attributed, at least in part, to discrepancies in the accurate determination of RMR, which could lead to overestimate the total energy requirement of healthy, overweight and obese individuals, thereby, predisposing children and young adults to the development of obesity-related comorbidities. Consequently, it is pivotal not only to determine the dietary and non-dietary risk factors of overweight and obesity in young populations, but also to accurately determine RMR and total energy requirements as well as to identify possible confounding factors that could influence the accuracy of the predicted RMR, including, but not limited to genetic variation [14] and lean body mass [15], which might be the first step toward the prevention or at least amelioration of obesity and its sequelae [3,14].

Validating RMR predication equations in different populations is warranted, on the other hand, studies that examine the accuracy and applicability of RMR predictive equations in young healthy populations remain scarce [4]. Validating RMR prediction equations in young, healthy Jordanians has yet not been investigated. Therefore, this study aimed in determining the accuracy of Harris–Benedict, FAO/WHO/UNU, Mifflin, and Owen predictive RMR equations in a group of young obese and non-obese healthy Jordanians. The findings of this study would then be used to plan for appropriate public health policies and dietary interventions; such as calculating energy requirements among youth, help establish vigorous models of weight gain and loss and expedite the calibration of individualized medical nutrition interventions.

2. Materials and methods

2.1. Study design and human participants

This study was carried out in Jordan at the Obesity and Metabolomics Laboratory, Hamdi Mango Center for Scientific Research at the University of Jordan. A total of 406 (200 females and 206 males), apparently healthy university undergraduate students (18–25 years) were recruited from all 19 academic faculties of the University of Jordan, which is the largest state university in Jordan with more than 42,000 enrolled undergraduate students admitted from all over the country. The current sample size was allocated according to the population of the University of Jordan using the population sample size equation provided by Oveson [16].

The investigators of the study directly contacted potential participants either in person, by giving a presentation to a group or on the internet postings. In addition, advertisements, flyers, information sheets and notices were posted on faculties' bulletin boards, after the text was approved by the Deanship of Students Affairs, the University of Jordan.

Participants gave a written consent before inclusion and were provided with a brief verbal explanation regarding the objectives and methods of the study. Students with acute or chronic illnesses, receiving any medical treatments, having weight alteration within the last three months of the study or were underweight (BMI <18.5 kg/m^2) were excluded from the study, likewise, pregnant or lactating females were also excluded [4,9].

In a follow-up session, body weight (kg) and height (cm), waist circumference (WC), and hip circumference (HC) were measured using standard procedures. Waist-to-hip ratio (WHR) and body mass index (BMI) were calculated. Male and female participants were categorized into three groups: normal bodyweight, overweight and obese according to the WHO classifications [18]. All measurements were performed according to WHO protocol [19]. The study protocol was approved by the Human Research Ethics Committee of Hamdi Mango Center for Scientific Research.

2.2. Resting metabolic rate

Resting metabolic rate (RMR) was measured between 9 and 12 a.m. at two sessions in non-consecutive days using indirect calorimeter (MetaCheck, KORR Medical Technologies Inc, UT, USA) which was calibrated before each test. Measurements were performed following an overnight fasting (10–12 h) under thermoneutral conditions that keep body temperature at an optimum point at which the least amount of oxygen is consumed for metabolism (in a 22–25 °C room temperature) [20]. Participants were asked to breathe through a sterile mouthpiece with nostrils occluded attached to a sensor that measures the volume and oxygen extraction. Measurements were performed while participants were at rest in a supine position for at least 10 min.

This paper will refer to “predicted RMR” for RMR predicted by the RMR prediction equations, and “measured RMR” for RMR measured by indirect calorimetry. Four equations were used to predict RMR: Harris–Benedict [7], FAO/WHO/UNU [5], Mifflin [6] and Owen [8]. RMR predicted values (kcal/day) were calculated. All equations were performed using weight in kg, height in cm, and age in years.

Harris–Benedict equation [7]

$$\mathrm{RMR\ (for\ males)} = 66.473 + [13.752 \times \mathrm{Weight}] + [5.003 \times \mathrm{Height}] - [6.755 \times \mathrm{Age}]$$

$$\mathrm{RMR\ (for\ females)} = 655.096 + [9.563 \times \mathrm{Weight}] + [1.850 \times \mathrm{Height}] - [4.676 \times \mathrm{Age}]$$

FAO/WHO/UNU equation (18–30 years) [5]

$$RMR\ (for\ males) = 15.3 \times weight + 679$$

$$RMR\ (for\ females) = 14.7 \times weight + 469$$

Mifflin equation [6]

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